

JAN 5 1967

National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-12487

USS-10

ST-PR-LPS-10 545

GPO PRICE \$ _____

CFSTI PRICE(S) \$ _____

Hard copy (HC) 3.00

Microfiche (MF) _____

ff 653 July 65

LUNA - 13 IS ON THE MOON

(Press Releases)

[USSR]

N67 18043

FACILITY FORM 602

(ACCESSION NUMBER)
14
(PAGES)
CR 81-205
(NASA CR OR TMX OR AD NUMBER)

(THRU)
None
(CODE)
31
(CATEGORY)

4 JANUARY 1967

L U N A - 1 3 I S O N T H E M O O N *

Excerpts from TASS Communiques
published in the Soviet Press
between 25 and 31 December 1966

Comments by
Prof. Yu. N. Lipskiy
Prof. A. I. Lebedinskiy

S U M M A R Y

This paper summarizes the various Tass communiques relative to the soft landing on the Moon of the new automatic lunar station (ALS) LUNA-13 on the evening of 24 December 1966.

The first photographs transmitted are presented herewith in their order of publication. An improved picture of the section I of the panorama was transmitted on 31 December 1966.

Except for the direct study of the solidity and constitution of the lunar surface layer by driving a rod into its surface on command, and of which the devices and procedures are described in detail, the performance of LUNA-13 is in every way analogous to that of LUNA-9. It corroborates the earlier findings concerning the absence on the Moon of a dust layer. The data on the structure of the ground lead to the same conclusions as those of LUNA-9 and SURVEYOR-1.

The photographs are the object of comments by Professors Yu. N. Lipskiy^{147/502} and A. I. Lebedinskiy.

On 31 December the last TASS communique announced that as of that date LUNA-13 has successfully completed its mission.

On the whole the present results are only preliminary. Subsequent papers will be published as the study of the data is pursued.

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The carrier-rocket started on 21 December 1966 at 1317 hours Moscow time, placed the automatic station LUNA-13 and the rocket block into an intermediate orbit of an AES, the latter imparting at a precise moment of time a velocity to the former, required for the flight to Moon trajectory.

* LUNA-13—NA LUNE!

According to data computed by the Coordinating and Computing Center, correction of station's motion was performed on 22 December 1966, as a result of which the new flight trajectory practically passed through the computed landing point.

Preparation for deceleration and braking was started two hours prior to landing time.- The retrorocket was switched on at 2059 hours after the station was re-oriented in space, and the station effected the soft landing at 2101 hours on 24 December 1966 in the region of Oceanus Procellarum (see Figs 4 and 5).

Approximately 4 minutes after landing the station was brought into the operational position and radiocommunication sessions have begun. According to telemetry indications all the systems operated normally with temperature and pressure on board within the preassigned ranges.

The place of landing was at a distance of about 400 km from the landing point of ALS LUNA-9. The morphological difference of both stations' landing sites is worth noting. If LUNA-9 descended in the direct vicinity of the eastern borderline of the continental shield, spreading to the entire far hemisphere, the landing site of LUNA-13 is located on a broad plain or lowland of mare type.

The nearest formations are the Seleucus (diameter 43 km) and the Schiaparelli (diameter 24 km) craters. Around the landing site no formations are seen within an area of about of 100 km, of which the dimensions would exceed 3.5 km. Moreover, the absence of sufficiently coarse formations, rising above the surrounding locality, should be underscored. On the last photograph presented (Fig.6) this case is manifest by the fact that the line of the horizon has a quiet (smooth) character.

The most interesting peculiarity of the landing region, known from ground observations, is the abundance of the so-called clefts (hollows of significant extension, having tens of kilometers in length). They are disposed in diverging beams and have a direction from the southwest to the northeast. The large number of clear spots observed in that region is evidence of the presence of local clusters of various types of hollows.

The soft landing of LUNA-13 was achieved prior to sunrise, this taking place at 0330 hours Moscow time on 25 December. The landing region being near the equator, the Sun rose there nearly outright relative to horizon line, whereupon its height increased by 0.5° each hour. Prior to the passage of the Sun through zenith the shadows from objects moving from East to West (and after noontime — from west to east) hardly changed their direction. Consequently, there exists a simple possibility of orienting the fragments of the panorama by sides of light. The photograph presented here (Fig.6) represents the moonscape in the southerly direction from the station. It was obtained during the third session. By the transmission time of the first images of the surrounding locality the height of the Sun was of 6° . During the second session it was 19° , and, finally, the published fragment of the panorama was obtained with the Sun at 32° above the horizon. The visibility of details of the moonscape is dependent on the illumination conditions to a very strong degree. This peculiarity was already known from ground observations. The greatest amount of light is scattered by lunar soil

in the direction of the Sun. The lower the Sun the more sharply this property is manifest. This means that the moonscape brightness rises strongly if the observation is conducted from the side of the Sun. As a result, a clear halo appeared around the shadow of the station in the second panorama, i. e. the one transmitted during the second session.

Preliminary analysis of the images obtained shows that the structure of the soil at the landing site of LUNA-13 is in many respects similar to that observed during landings of LUNA-9 and SURVEYOR-1, the latter having effected a soft landing last summer in the region of the Flamstead crater. At closer consideration the surface is found to be strongly dug up with separate grains of several millimeter dimensions. Again the absence of dust on the Moon has been corroborated.

There are observed in the vicinity of the station a series of formations of crater type, and also a substantial number of stones of several centimeter dimensions and more. The study of the disposition of these formations confirms the conclusion that the stones fell on its surface with low velocity. Their source may have been either a volcanic eruption, or the formation of a primary crater as a result of meteoritic impact. Moreover, the trajectory of the fall was sufficiently steep, for otherwise (at slanting trajectory) traces would have remained on the surface, directed toward the source of stone ejection. Consequently, the mineralogical composition of the stone is analogous to that of the soil. They are without doubt not meteorites: the collision velocity of the latter with the lunar surface cannot be less than 2.4 km/sec, which leads inescapably to explosion with formation of crater-like hollow on the surface.

On the published photograph (Fig.6) one may easily see a group of stones having apparently formed during the fall of a monolithic fragment (see the upper left angle). In the lower left-hand part of the photograph one may clearly see the long shadow from a stone of quite a remarkable shape: it is flat, as if it protruded from the ground. Besides, certain details of the station, discarded during landing, can be seen on the photographs.

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From the standpoint of construction the ALS LUNA-13 has a series of differences compared with its predecessor LUNA-9. The experience gained from the operation of the latter, also landed softly on the surface of the Moon, has allowed to improve considerably the construction of LUNA-13, whereas the solution of a series of scientific problems has required providing the station with a new scientific apparatus.

A frame with receiving-transmitting radiodevices, electronic program-temporal devices, chemical batteries, automation, scientific and telemetry devices and a thermoregulating system is placed on LUNA-13 inside a hermetic container.

Four petal and four collapsible-whip antennas were fastened outside the body or frame of LUNA-13 alongside with TV and two "bearing out" mechanisms.

Prior to bringing the ALS into the operational position the petal and the collapsible-whip antennas, and also the television and apparatus' bearing out mechanism were in mounted folded position and were so maintained by a special lock. They were brought into operational condition on command from the on-board program-temporal device, whereupon as the lock was disengaged, antennas, as well as the bearing out mechanism opened up. At the end of one of these mechanisms was installed a stamp (punch) groundmeter, and on the other a radiation densimeter. The bearing out mechanisms allowed to install the ground- and the densimeter on the surface of the Moon at the distance of 1.5 meters from the ALS.

The television system of LUNA-13 is a scanning device, close in its construction to those of mechanical TV or photo-teleggraphy. It should be noted that the optico-mechanical system satisfies the hard requirements of weight, size, energy consumption and operational reliability expected of ALS devices.

The full circular scanning time of the TV camera is about 100 minutes, the depth of the outlined space is from 1.5 m to infinity; this allowed to distinguish details of 1.5 - 2 mm dimensions at the distance of 1.5 meters.

The television apparatus is provided with an automatic regulation of signal's amplification factor as a function of illumination of lunar surface. The axis of this device was inclined at 16° to the local vertical on a sufficiently smooth horizontal surface. This created favorable conditions for the transmission of microrelief objects.

In order to ensure the required temperature regimes of LUNA-13, a special type active thermoregulation system was utilized. This was switched on immediately upon ALS' landing on the Moon. Under the effect of gas pressure inside the ALS the water of the soft tank headed toward the evaporation valve, the latter functioning at the same time as heat exchanger. As water evaporated, the heat liberated by the devices in the course of their operation was absorbed in the evaporation valve. The latter's tune up allowed sustaining the station's temperature within the range from 19 to 30°C .

In order to fulfill the program of scientific investigations a punch groundmeter was especially designed for the study of the outermost layer of lunar matter (within the range of a few centimeters); moreover, there was installed a dynamograph registering the duration and the magnitude of the dynamic overload impulse arising during the landing of ALS on the lunar surface, and a radiation densimeter allowing to determine the specific weight (density) of lunar matter.

The combined measurements with the aid of these devices allowed us to obtain multilateral data on physico-mechanical properties of the lunar surface at landing point.

The ALS was also equipped with a device for the registration of cosmic rays; it was especially designed for extending the investigations of the radiation setup near the lunar surface, already begun with the aid of LUNA-9.

The measuring punch-groundmeter had a conical tip made of titanium. It was connected with a small gunpowder rocket, developing in the course of one second a force of 7 kg, under the action of which the stamp (punch) penetrates the surface of the soil.

The dynamograph consisted of piezoelectric overload sensors and of an electron circuit memorizing the duration and the magnitude of the impulse of acceleration generated at landing.

The mechanical properties of the surface of the Moon at the point of landing were estimated by these parameters, for a short overload impulse with great amplitude corresponds to a hard surface, whereas a longer one, of correspondingly smaller amplitude, corresponds to a soft surface.

The preliminary comparison of the acceleration impulse obtained with the results of model experiments conducted in terrestrial conditions, provides us with the basis to consider that the mechanical properties of the Moon's surface layer with depth from 20 to 30 centimeters are close to the properties of the terrestrial soil of average density.

Alongside with measurements of mechanical properties, the data on lunar matter density (specific weight) also offered interest. It is well known that the average volumetric weight of lunar matter (for the Moon as a whole), determined by the data of astronomical observations is lower than the mean volumetric weight of terrestrial matter (3.34 g/cm^3 against 5.51 g/cm^3 for the Earth). The density of the external layer of the Moon was investigated to-date only by astronomical methods; the first direct measurements of the volumetric weight of the superficial layer of the Moon were performed by LUNA-13.

The lunar matter density measuring device ("radiation densimeter", see Fig.7) includes:

- a small radioactive source of γ -radiation;
- three blocks of gas-discharge counters of γ -quanta;
- a screen shielding the gas-discharge counters from direct hitting by γ -rays of the source.

As the densimeter contacts the lunar surface, the latter is irradiated by γ -quanta originating from the source and scatters them in all directions. A specific part of scattered quanta hit the device's gas-discharge counters which measure the intensity of the scattered flux. It is well known that the intensity of the flux of scattered γ -quanta is proportional to the density (specific weight) of lunar matter. According to the preliminary data the flux intensity of γ -quanta scattered by the surface of the Moon corresponds to the density not exceeding 1 g/cm^3 , i. e. substantially lower than the density of terrestrial soils and the mean density of the Moon. The quantity measured is close to the density of porous or granular, little bound rocks.

The device installed on LUNA-13 for the registration of cosmic corpuscular radiation consisted of gas-discharge counters, switched on coincidence. Contrary to the apparatus of LUNA-9, such a device did not register the γ -radiation, but

only the charged particles included in the composition of corpuscular radiation and allowed to determine the albedo of the lunar surface for cosmic rays. It was found that the lunar surface "reflects" nearly 25 percent of particles, incident upon it from the outer space. This takes place because there are in the composition of cosmic radiation particles of substantial energy. When such particles traverse the lunar matter, secondary particles are formed, which obtain part of the energy of the former. Some of these secondary particles move in a direction constituting a notable angle with that of primary particles. Therefore, it looks as if the Moon somehow "glows" under the action of cosmic rays, emitting particles endowed with substantial energy. However, these measurements have shown that the total intensity of particles of high energy on the Moon is small when the state of the Sun is quiet.

The same device of the station LUNA-13 confirms the conclusion on the low radioactivity of the lunar surface, already obtained by an analogous method on LUNA-9.

Now there no longer is any doubt that spacecrafts are precisely the devices which will allow us to resolve such most important problems of science as the origin of the solar system, the emergence and the development of life on other planets and the inner structure of celestial bodies.

In this plan the attention afforded to the Moon is explained not only by the fact that it is the closest to us heavenly body, and consequently the most practical for various experiments, but also because by a series of its characteristics the satellite of our Earth is typical of the group of bodies of the solar system.

Therefore, the new investigations of the Moon constitute an important stage on the path to subsequent clues of the Cosmos.

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(Follow several plates relative to latest photographs of the Moon's surface transmitted by LUNA-13, with comments by Professors Yu. N. Lipskiy, and A. I. Lebedinskiy).

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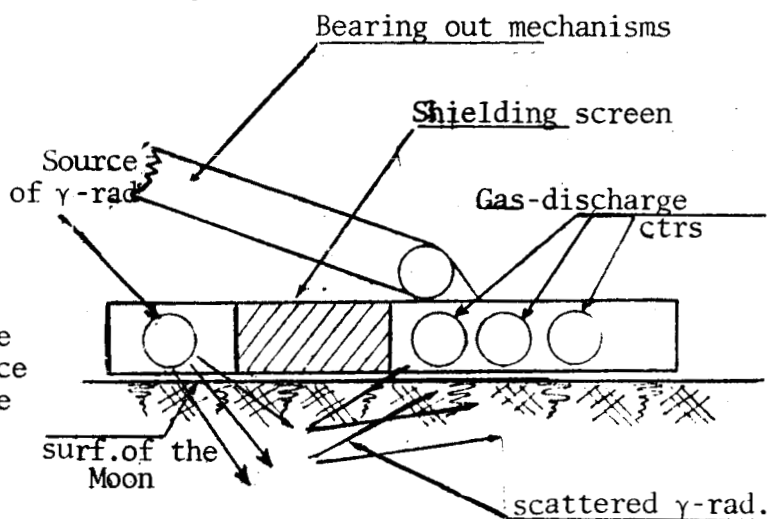


Fig. . Radiation Densimeter

COMMENTS BY PROF. Yu. N. LIPSKIY

A fragment of the lunar panorama is shown in Fig.1.* It was transmitted by the Soviet lunar (interplanetary) automatic station (ALS) LUNA-13, having effected a soft landing in the Oceanus Procellarum on 24 December 1966 at 21 hours 01 minutes Moscow Time.

The region of landing site is situated between the Kraft and Seleucus craters, to the southeast of the latter. The coordinates of the point of landing are: $18^{\circ}52'$ Northern latitude and $62^{\circ}03'$ Western longitude. This region is one of the most interesting parts of Oceanus Procellarum: here the relatively smooth mare surface abounds in rather extended hollows and clefts. In some respect this region reminds one of that situated near Mare Orientalis, which has been shown with exceptionally interesting details in the photograph released by the Soviet interplanetary station "ZOND-3".

In the present photograph the microstructure is seen as clearly as in the panoramas of LUNA-9. A crater-like hollow with step-shaped slopes is clearly seen in the right-hand part of the photograph. These slopes are covered in their turn by tiny hollows. A distinctly linear (ruled) structure is sharply outlined in the region of the right-hand corner of the photograph, near the solitary stone; this structure is parallel to the lower edge of the photograph. Shadows of parts of the station are clearly seen.

The fragments of the panorama of LUNA-13 corroborate the conclusion drawn from these of LUNA-9 relative to the absence on the surface of the Moon of a powerful dust layer. Not only is the dust invisible on the ground roughnesses; its absence is also evident on the various parts of the probe. Normally, upon landing on the lunar surface, dust ought to have covered the station's unit under the effect of the electrostatic field induced by the electric charges having accumulated on the station during flight, as well as on the Moon. The sharpness of the image is evidence that the lens too was free of dust.

A large number of stones can be seen on the photographs. Their shape and the outlines are evidence of their relative monolithic structure. It is quite obvious that they could not have arisen as a result of conglomeration of tiny particles in lunar vacuum. Nor can these stones be meteorites having fallen on the lunar surface. The minimum velocity with which meteorites may collide with the lunar surface exceeds 2.4 km/sec. As to the mean velocity it apparently constitutes 12 to 15 km/sec. Such collision velocities inescapably lead to explosion with formation of hollows — the primary craters.

The presence of stones lying on the very surface of the soil, practically without hollows, corroborates besides all this the earlier conclusion derived on the basis of information from Luna-9 concerning the relative solidity of the lunar soil. As to the origin of stones, their source might have been some volcanic eruption, or else, they may have been ejected during the formation of primary

* Since the publication of this note, a better picture was transmitted and published on 31 December 1966 (see Fig.6)

craters having arisen as a result of meteoritic impact. Since the photographs of the portions of the surface transmitted by the stations LUNA-9 and LUNA-13 are related to different areas of the Oceanus Procellarum, the substantial number of stones in them is evidence of abundance of these formations on the surface of the Moon.

The subsequent study of the material from LUNA-13 promises numerous important conclusions concerning the structural peculiarities of the lunar surface.

Published on 26 December 1966

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COMMENTS BY PROFESSOR A. I. LEBEDINSKIY

The Figures 1 and 2 (and subsequently Fig.6) present part of the lunar panorama transmitted by ALS LUNA-13. The transmission began on 26 December 1966 at 1630 hours Moscow Time. It lasted 100 minutes on that day. During this time the TV camera effected a total convolution about its axis. In correspondence with the construction of the station this axis is inclined with respect to the lunar vertical. When the station stands on a hard horizontal surface, the inclination angle is of 16° . In fact it is close to that value. The inclination of the axis allows us to somehow visualize the "eye" of the TV camera closer to the ground, and this is why the nearest portions of the panorama (lower central part) are photographed from a distance of less than one meter, so that details of millimeter dimension of ground structure may be noticed. As one draws farther away from the camera, upward in the photograph) the image's scale decreases rapidly, and the stones, seemingly small in the upper part of the picture, have in reality coarser dimensions than the largest details in the forward plane.

The panorama height is about 30° . The area represented in the picture has an extension by azimuth of about 220° . Because of TV camera's axis inclination the horizon line is curved. In the central part of the photograph, that is, in the direction where the axis of the camera is inclined, the image of the lunar surface fills the entire visual field and the horizon can not be seen. As one draws away on both sides, the image of the black lunar sky occupies a greater and greater part of the photograph..

A series of details of the station itself can be seen in the forward plane of the photograph. The most noticeable unit is the mechanical ground meter and the mechanism bringing it away from the station by a certain distance. Part of this "bearing-out" mechanism is colored in white and the rest in black paint. In the photograph obtained on 25 December the white part was in station's shadow, but the ground could be seen illuminated by the Sun through an aperture in the bearing-out mechanism. Seen on the portion of the surface in the panorama are two directional antennas (there are 4 of them) and the round end of one of the petal antennas. Removed from the station are two coils ejected as the station opens up. As to the contours of the station, they can be judged from their shadows. Seen clearly are the shadows of the four directional antennas with the

with the tapes fastened to their ends, and also the shadow of the groundmeter with its associated bearing-out mechanism.

During the 26 December transmission the height of the Sun above the lunar horizon was about 19° and the length of the shadows exceeded the height of the objects rejecting these shadows by about a factor of three. Such illumination conditions were favorable for the study of the structure of the lunar surface. At lower heights of the Sun numerous details would be lost in the shadows, and at greater heights of Sun the shadow do not outline the soil's roughnesses as sharply.

The station LUNA-13 is located in a hollow, probably a small crater with radius of a few meters. The wall of this crater is noticeable in the right-hand as well as in the left-hand parts of the portion of the panorama represented in the picture and stretches approximately parallelwise to the visible horizon, but by about 3 to 4° below it. The details seen beyond the crater's wall are situated farther from the station and this is why they appear to be tinier than those of the inner slope of the crater.

The station LUNA-9 was found to be located in a similar crater, but with diameter of about 15 meters.

The microstructure of the lunar surface is clearly seen on the panoramic photograph (Fig.2, I, II, III). Tiny craters of irregular shape and with dimensions from the decimeter and up arouse attention in the right-hand part. There are numerous stones in the visual field. Particularly interesting is the group of stones near the left-hand edge of the panorama. Visible also are numerous clefts and elongated irregularities of the ground.

LUNA-13 landed in the territory of Oceanus Procellarum, just as was the case for LUNA-9. However, judging from the charts composed on the basis of telescopic observations, the character of the region of landing may be different for both probes. LUNA-9 was found to be in the boundary region, where the mare moonscape passes to the continental type. As to LUNA-13, it came down in a region with typical mare properties. Comparison of the microrelief in these regions will have a great scientific significance.

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On 31 December 1966 the TASS Agency announced that as of that date LUNA-13 has completed its mission successfully, having obtained as a result of the studies carried out unique data on physico-mechanical properties of the Moon's surface layer, constituting a great scientific value. Television pictures of the panorama of the lunar surface in the landing site region were transmitted at various heights of the Sun. The obtained scientific information is being processed.

*** THE END ***

Photograph transmitted by LUNA-13

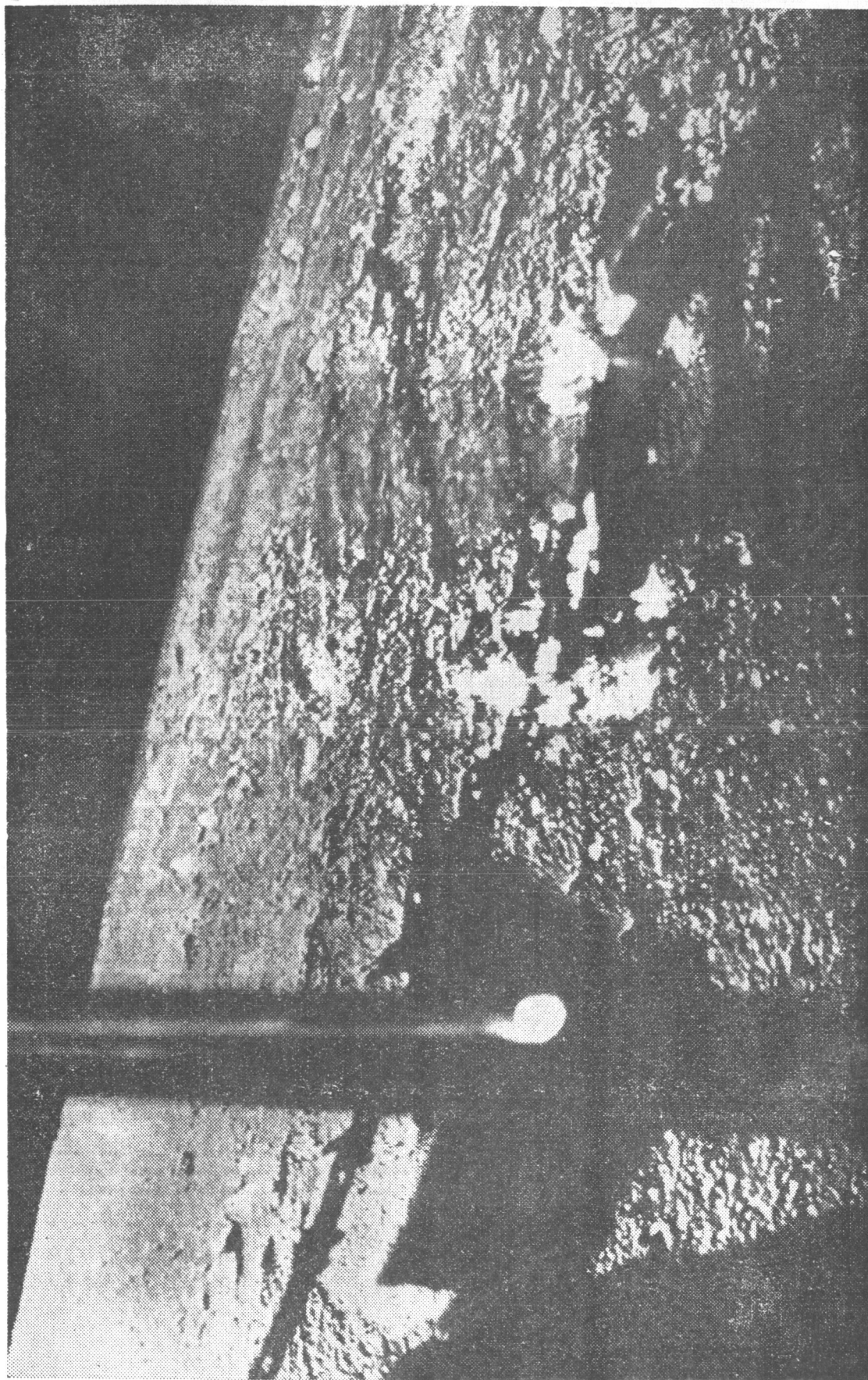
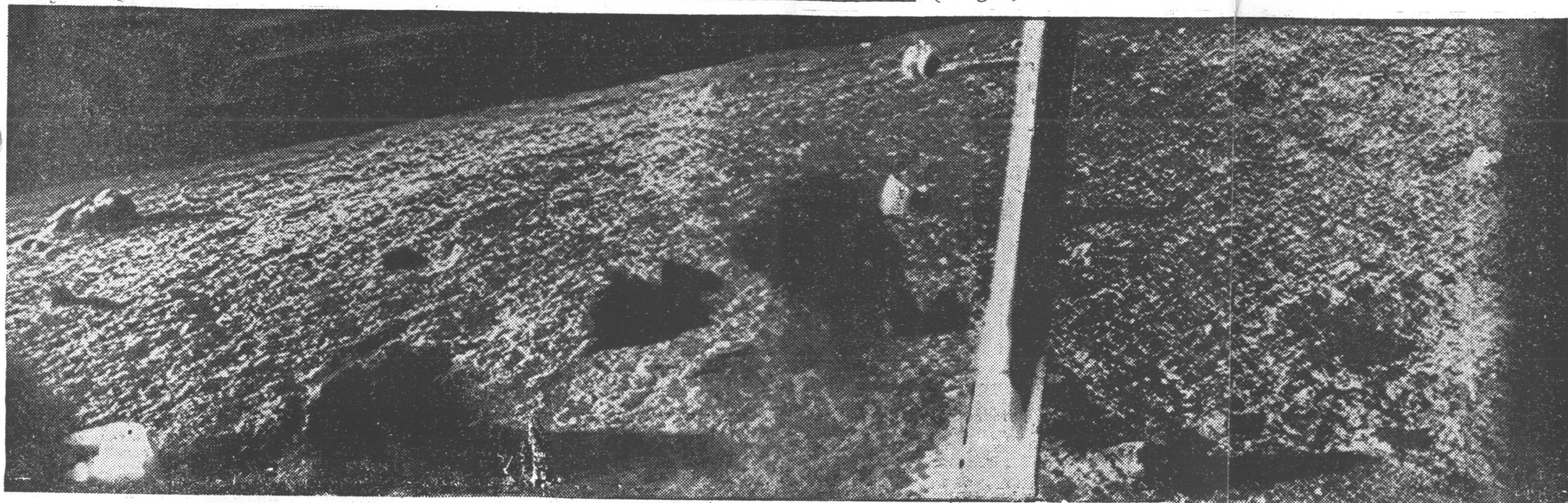
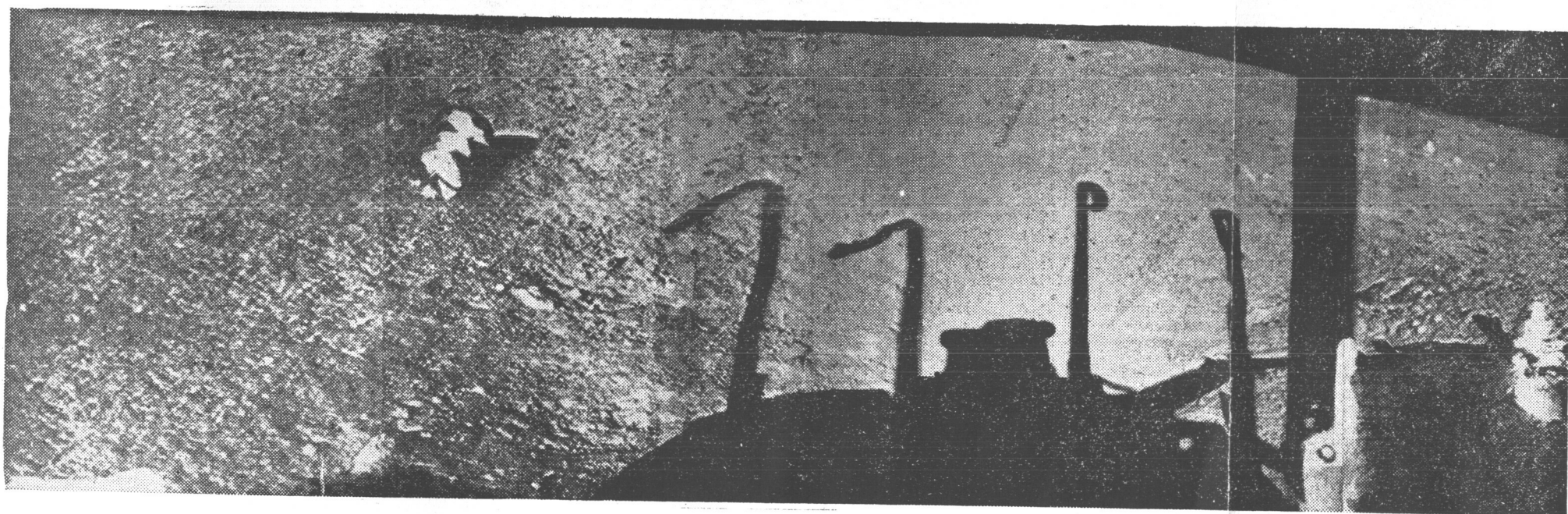


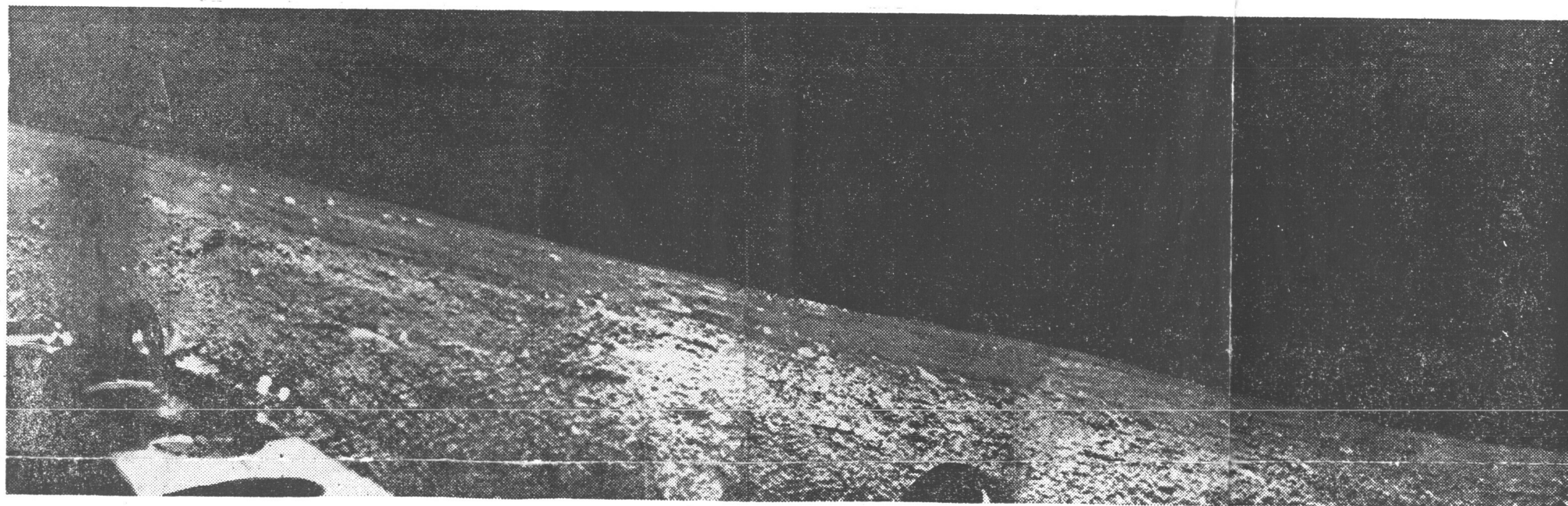
Fig.1



I



II



III

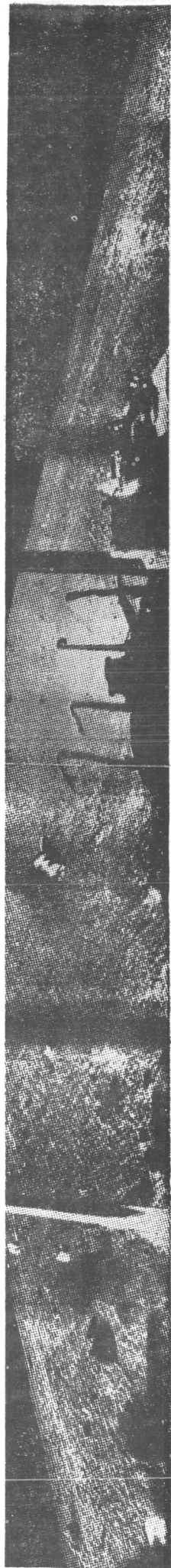


Fig. 3. Panorama of the lunar surface (I, II, III of Fig.2) transmitted by LUNA-13

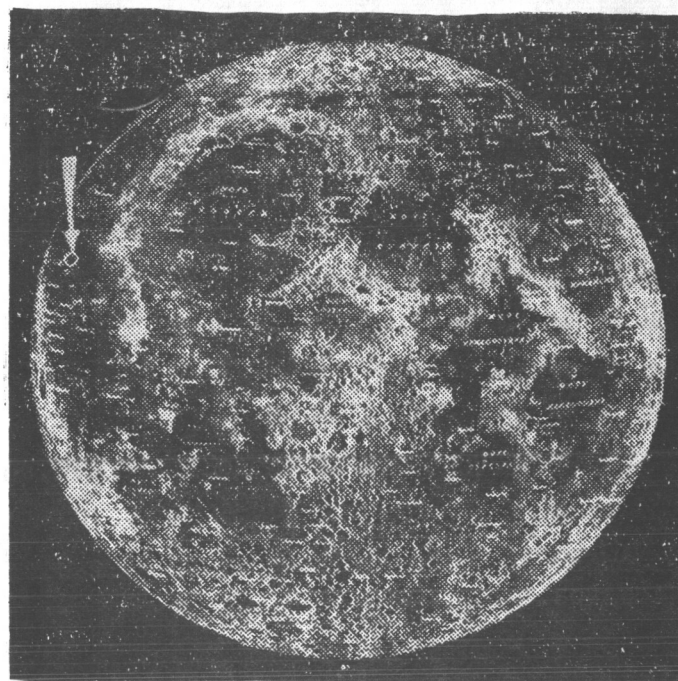


Fig.4. The visible side of the Moon.
The arrow indicates the landing point
of LUNA-13

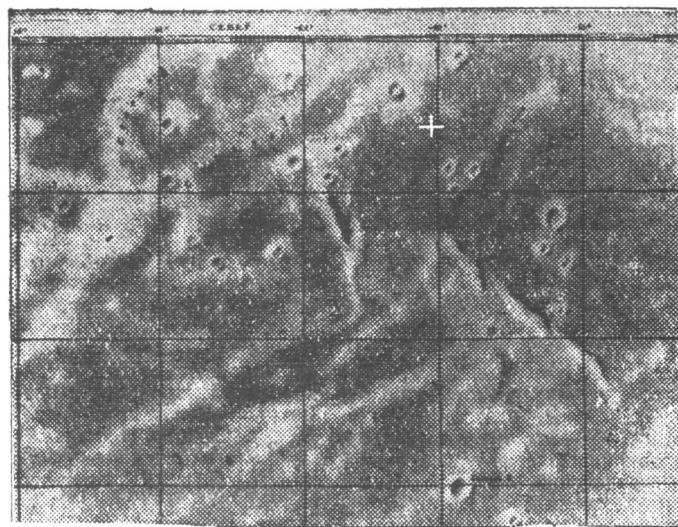


Fig.5. Selenographic coordinates of
the point of landing of LUNA-13 marked
by a white cross:
18°52' Northern latitude, 62°03' Western
longitude. Dimension of net's square:
60 by 60 km

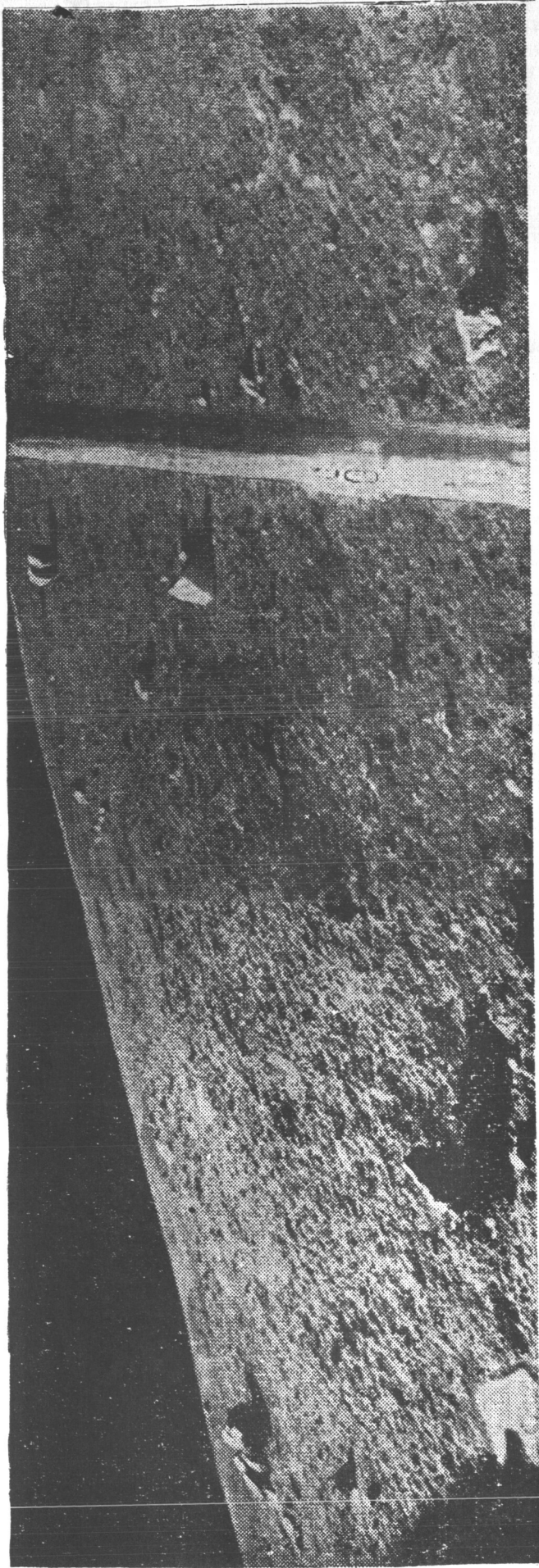
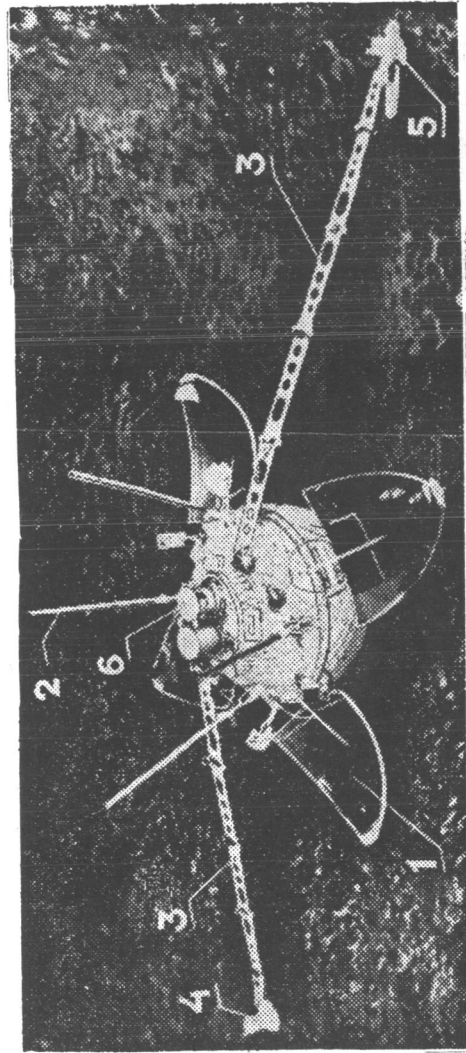


Fig.6. New photograph of the fragment I of the panorama transmitted by LUNA-13 and published on 31 December 1966



Sketch of the automatic station LUNA-13.
 1) Petal antennas. 2) Collapsible-whip antennas. 3) Bearing out mechanism. 4) Soil meter.
 5) Radiation densimeter. 6) Television camera